In this Issue

On the Cover

Water and health officials are striving to find the best way to detect and kill *Cryptosporidium.*

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Editor's Desk

Water with problems is better than no water," said the late California Governor "Pat" Brown in defense of the controversial State Water Project (SWP) authorized by voters in 1960. Thirty-six years later, a historic step toward solving some of the habitat problems associated with the state and federal projects was made when voters passed Proposition 204 in the recent election. The new water bond represents the largest step toward a comprehensive solution of the state's water problems since the 1960 act and it's the most money appropriated by voters since that $1.75 billion bond.

Harvey Banks, a well-respected water engineer who supported both historic bonds, recently died. He was best known for his efforts to get the SWP built as the first director of the Department of Water Resources. In later years, Harvey served on the Foundation's board of directors. I liked him because he didn't live in the past. He respected the emerging ideas about environmental protection and recognized that the water projects were associated with some problems. Harvey's widow asked that contributions in Harvey's name be donated to the Foundation. We'll use the money to fund a program in his name, reflecting his dedication to the Foundation and California water.

We lost another colleague recently with the death of Adolph Moskovitz, a prominent attorney who helped shape California water law. Adolph was a founding partner of the widely known capital law firm, Kronick, Moskovitz, Tiedemann and Girard. We honored Adolph this year at our attorney's briefing. Our hearts go out to Adolph's and Harvey's families.

Harvey Banks

Recently, I sat down with 87-year-old Clair Hill, another longtime water leader, and interviewed him on video about his fascinating memories of the water resources of the north state and building the projects, including Shasta Dam. Like Harvey, Clair is an engineer who spent his life in water development. He was one of the founders of CH2M Hill Engineering and a long-time member of the California Water Commission. The recording was sponsored by a grant from the **McConnell Foundation** of Redding and copies of the tape and transcript will be available from us.

Rita Sudman with Clair Hill

As we move into a new year with a mandate from the people of California for water improvements, it's a good time for us at the Foundation to look to the future with development of our **Water Leaders Class** (see page 14). I hope that today's leaders in the agricultural, urban and environmental water worlds will become mentors for these younger people as the older water leaders served to mentor me and the staff at the Foundation.

Best wishes from all of us at the Foundation for a Happy New Year and for a "normal" water year!

Rita Schmidt Sudman

In the News

Proposition 204: What's Next?

With 63 percent in favor, California voters approved the state's second-largest water bond in history in the recent election. Proposition 204, the "Safe, Clean, Reliable Water Supply Act," authorized a $995 million general obligation bond to finance key water quality and environmental improvements with a special focus on the Sacramento-San Joaquin Delta.

"This is a historic moment in California's water history and represents the largest step toward a comprehensive solution to the state's water supply problems since the development of the State Water Project in 1960," said state Sen. Jim Costa, D-Fresno, author of the measure.

With passage of the measure comes a new question: how to spend the money. Three days after the Nov. 5 election, the first meeting of the newly formed Ecosystem Roundtable was held.

The members of this stakeholder group, co-chaired by Gary Bobker of the Bay Institute, Greg Gartrell of Contra Costa Water District and Jason Peltier of Central Valley Project Water Association, will help identify and select ecosystem restoration projects to be funded by Proposition 204.

Stakeholders also are expected to pursue federal funding. Shortly before the election, Congress approved a bill authorizing expenditure of $143 million a year for three years for Delta restoration. That money, however, must still be appropriated.

About half of the state bond measure is dedicated to Delta improvements, with $193 million available for immediate expenditure. This portion includes $93 million to finance California's share of implementation of the federal CVP Improvement Act. Other programs that will receive money are Category III Delta environmental projects, $60 million; Delta levee improvements, $25 million and South Delta barriers, $10 million.

At the California Chamber of Commerce's recent water resources committee meeting, Steve Hall, executive director of the Association of California Water Agencies, said Proposition 204 is something of a gamble that "if we invest a lot of money in improving the environment and the habitat for endangered species, those species will recover.

"If they don't recover or the wildlife agencies don't recognize that they've recovered," Hall said, "then Proposition 204 does us little good."

The bond measure also includes $235 million to provide loans and grants to communities to finance construction of wastewater treatment plants, water recycling projects and agricultural drainage treatment works. The Flood Control Subvention Program will receive $60 million.

The remaining $390 million will finance the future CALFED Bay-Delta Ecosystem Restoration program. This money, however, cannot be spent unless certain milestones are reached.

The general obligation bond will be repaid with tax dollars over 30 years. Repayment of the bonds, according to the legislative analyst's office, would total about $1.8 billion or $71 million a year. ■

November 9
State of the Sacramento River Conference
Sacramento River Preservation Trust
Sue McClurg, panel moderator
Red Bluff, CA

November 13
"Politics of Achieving Consensus on Calif. Water"
Pat Brown Institute of Public Affairs
Rita Sudman, speaker
CSU, Los Angeles

November 14
California Water Policy VI conference
POWER, Public Officials for Water and Environmental Reform
Rita Sudman, panel moderator
Los Angeles, CA

November 19-20
California State Association of Counties
Rita Sudman, panel moderator
Valerie Holcomb, committee meeting
San Diego, CA

November 21
Groundwater workshop
Judy Wheatley, presenter
Redding, CA

November 24-26
National Groundwater Conference
Groundwater Foundation, sponsor
Rita Sudman, management team
Oak Brook, IL

November 26
Project WET Workshop
Judy Wheatley, California coordinator
Clarksburg, CA

December 3
WEF Board of Directors Meeting
Henry Vaux Jr., president
San Diego, CA

December 6
UC Centers for Water and Wildland Resources Advisory Council Meeting
Rita Sudman, member
Oakland, CA

by Sue McClurg

The Challenge of *Cryptosporidium*

"With the debate over chlorine disinfection byproducts and cancer, we lost sight of the fact that all of this modern, sanitary practice is set up to protect us from the transmittal of human disease. Milwaukee woke us up."

— Steve Leonard
San Francisco Public Utilities Commission

Despite its microscopic size, *Cryptosporidium parvum* has had a big impact on the drinking water industry.

Since 1984, scientists have linked 11 outbreaks of cryptosporidiosis, the disease caused by *Cryptosporidium*, in the United States to local drinking water supplies. The worst outbreak occurred in 1993 when *Cryptosporidium* invaded the city of Milwaukee's drinking water plant and survived the treatment process, sickening 400,000 people and causing at least 69 related deaths.

In a society in which tap water has been viewed as safe from waterborne illnesses since the advent of chlorination in the 1900s, it was a rude awakening.

"With the debate over chlorine disinfection byproducts and cancer, we lost sight of the fact that all of this modern, sanitary practice is set up to protect us from the transmittal of human disease," said Steve Leonard, with the San Francisco Public Utilities Commission, which operates Hetch Hetchy Reservoir. "Milwaukee woke us up."

Cryptosporidium (pronounced "krip-toe-spore-i-dee-um"), a cause of traveler's diarrhea, is a parasite found in the feces of mammals, particularly young calves. It is spread through ingestion of water or food contaminated with feces, or contact with feces from an infected animal or person. Within two to 10 days of infection, symptoms of cryptosporidiosis — abdominal cramps and diarrhea — can occur. While unpleasant, it usually runs its course in one to two weeks, and many people dismiss the illness as the flu. But for people with weakened immune systems, cryptosporidiosis can be deadly because there is no effective medical treatment. The Milwaukee outbreak was responsible for the premature deaths of at least 69 persons, most of whom were HIV-positive, according to the Wisconsin Division of Health.

The main lesson learned from Milwaukee and most of the other outbreaks of waterborne cryptosporidiosis is that water treatment plants must be operated at the highest possible level to help guard against *Cryptosporidium*. The reason? The most widely used agent to disinfect tap water — chlorine — does not kill the parasite.

"Apparently, conventional chlorination processes alone are incapable of providing an adequate level of public health protection against crypto, especially when source water is of poor quality," Helena Solo-Gabriele and Shondra Newmeister wrote in the September 1996 issue of the *Journal* published by the American Water Works Association (AWWA).

Solo-Gabriele, an assistant professor at the University of Miami, and Newmeister, a graduate student at the University of Miami, reached that conclusion after researching 11 waterborne *Cryptosporidium* outbreaks that have occurred in the United States. The two researchers also recommend that drinking water be protected from the effects of wastewater and nonpoint sources of contamination, and that filtration systems be "operated at optimum levels exceeding existing regulatory requirements."

Yet even with a modern treatment system and good quality source water, a 1994 cryptosporidiosis outbreak in Las Vegas was statistically linked to the drinking water supply by the federal Centers for Disease Control and Prevention (CDC). Tests of the untreated and treated water at the time of the outbreak found no *Cryptosporidium*, however, and officials at the Southern Nevada Water Authority (SNWA) remain unconvinced drinking water was the source of the outbreak. "From a practical point of view, I can't see how it happened," said Joe Monscvitz, director of the SNWA treatment plant. "But if it did happen here without us identifying it in a pristine water supply, then it should be a major concern to everyone."

According to the CDC, *Cryptosporidium* — crypto for short — has been found in 65 percent to 97 percent of the nation's rivers, lakes and streams. Through data submitted by water districts conducting voluntary tests, California health officials have determined that the parasite can be found in low concentrations in the state's surface water. Although groundwater generally is considered safer from microbial contamination than surface water, five of the 11 waterborne crypto outbreaks occurred in systems where groundwater came in contact with sewage or contaminated surface water. Waterborne crypto outbreaks also have been documented in Canada and Europe.

While there have been no water supply-linked outbreaks of crypto in California, water agencies and health officials have taken steps to monitor for the parasite and enhance practices at existing water treatment plants to guard against any problems.

In the aftermath of Milwaukee, federal drinking water regulations are being developed that place more emphasis on *Cryptosporidium* and other microbial pathogens. In California, legislation signed into law in 1996 authorizes the state Department of Health Services to implement a program to assist water suppliers in reducing crypto risks.

Meanwhile, health officials continue to advise people with severely weakened immune systems caused by AIDS to either boil their tap water, or drink filtered water. Water suppliers and scientists are working to find more effective methods to detect and eradicate crypto.

Detection can be difficult. To begin, crypto oocysts (pronounced "oh-oh-sist") are only 3 microns to 7 microns in size — a micron is 1 millionth of a meter. (In comparison, *Giardia* cysts are about 15 microns.) The laboratory test to detect crypto is time-consuming and laborious. To further complicate the matter, there are several varieties of crypto, but only one — C. *parvum* — is infectious to humans. And the lab test cannot determine whether a crypto oocyst is alive or dead.

The hard shell or oocyst in which the parasite resides protects it in the environment; an oocyst can remain viable for up to six months. It is this same shell that protects the protozoa from chlorine. Currently, treatment of drinking water is limited to four basic options, or a combination of options:

- Protection of the raw water (in a reservoir, for example) from runoff that could contain crypto oocysts;
- Physical removal of crypto oocysts via filtration;
- Use of ozone gas rather than chlorine to disinfect the water and kill any crypto oocysts.
- Effective cross-connection control program in the distribution system.

There is considerable debate over the effectiveness of traditional filtration systems — coagulation, flocculation and sedimentation — to remove crypto. Membrane filters, which have extremely small openings, can provide a physical barrier but like ozone, the cost to rehabilitate a drinking water plant to use membranes is expensive. Because water districts are uncertain what standard they will need to meet once the U.S. Environmental Protection Agency (EPA) adopts a crypto rule, officials are hesitant to install equipment that could prove obsolete.

On another front, water suppliers must wrestle with a philosophical question. "Is it the responsibility of the water industry to protect the health of the most sensitive population?" asked Marco Aieta, senior vice president of Montgomery Watson. "The water industry is concerned about the protection of public health, but for the majority of the population, the water supply is safe if it meets

Only 3 to 5 microns in size, *Cryptosporidium parvum* oocysts, top, cannot be seen with the naked eye. The laboratory test to detect them is labor-intensive. Samples must be stained with a fluorescent dye and technicians must examine each slide manually under a microscope, scrutinizing particles that are the correct size to determine if they are crypto oocysts.

current regulatory standards. If a person has a fully compromised immune system, they know they have to be very careful, including with the water that they drink."

This issue of *Western Water* examines *Cryptosporidium* and drinking water. It provides background information on the parasite and its transmission, pending federal rules to reduce exposure through drinking water supplies, and water treatment options. More information about drinking water is available in the Foundation's *Layperson's Guide to Drinking Water*, which is being updated to include details of the 1996 amendments to the Safe Drinking Water Act (SDWA).

Background

Literally translated, *Cryptosporidium* means "mystery spore." It is an appropriate description for much about the parasite remains unknown. In fact, it wasn't recognized as a human pathogen until 1976, when the first case of cryptosporidiosis was diagnosed.

Early cases of the disease were associated with immuno-compromised people and the increase in the number of cases corresponds with the AIDS crisis of the early 1980s. Cryptosporidiosis remains a significant contributing cause of death for people with AIDS, primarily because the parasite persists and can produce a protracted course of diarrhea. Medical treatment consists only of supportive care through fluid replacement. For other people with low immunity, such as cancer patients or people undergoing an organ transplant, the infection can be more severe and last longer than in healthy people.

Scientists still do not know a lot about the infectious level of crypto, although studies indicate five to 10 cysts can make someone sick. Researchers have found antibodies for crypto in 20 percent to 30 percent of the population, which indicates they have been exposed to crypto. However, there is no way to determine if they were exposed to C. *parvum* and exhibited symptoms, or were exposed to another, noninfectious species of crypto.

Crypto oocysts are found in young mammals, and studies show that 50 percent of young calves shed the oocysts. If a calf defecates in a stream and that water is later ingested by a person, there are three possible developments. The oocyst may already be dead, thereby simply passing through the digestive system. The oocyst could be viable, but even after exiting its shell, the parasite may not produce an infection. In the third scenario, the oocyst is viable, exits its shell and attaches itself to the person's intestine, causing an illness.

In addition to drinking water, cryptosporidiosis can be spread by swallowing water while swimming in a contaminated lake or pool, person to person contact (for example, at a day care center), contact with the infected stool of an animal (for example, on a farm), or hand to mouth transfer from surfaces that may have been contaminated with an infected stool.

Current surveillance data indicate fewer than one reported cases of cryptosporidiosis occur per 50,000 people per year. Because it is a fairly new disease and doctors are not required to test for it or report it except in individual states (it has been a reportable disease in California since 1989), cryptosporidiosis, like other waterborne microbial diseases, may be more widespread. According to CDC data, for example, an estimated 940,000 incidents of waterborne disease occur each year from all microbial sources. A 1994 EPA study estimates more than 2 million cases of waterborne gastrointestinal illnesses occur each year.

The earliest crypto outbreak in the United States linked to drinking water, according to data compiled by Solo-Gabriele and Newmeister in the *Journal*, occurred in 1984 in Braun Station, Texas, when well water became contaminated with raw sewage, sickening an estimated 2,000 people. Four other outbreaks occurred between 1986 and 1992 in New Mexico, Georgia, Pennsylvania and Oregon, sickening a estimated total of 28,600 people.

Glossary

Cryptosporidium parvum — Microscopic, intestinal parasite commonly found in the feces of mammals, particularly young calves.

Cryptosporidiosis — A disease of the intestinal tract caused by the parasite C. *parvum*. Common symptoms include stomach cramps and diarrhea.

Disinfection byproducts — Chemicals produced during the standard chlorine disinfection drinking water process that are suspected to be human carcinogens.

Disinfectant and disinfection byproduct rule (D/DBP) — Rule being promulgated by EPA that would require water suppliers to reduce the levels of disinfection byproducts found in treated drinking water. Stage 1 of the rule will be delayed until at least 2000 with stage 2 following in 2003.

Enhanced surface water treatment rule (ESWTR) — Federal rule to be promulgated in 2000 proposing reduction criteria based on the number of *Cryptosporidium* oocysts in raw supplies.

Information collection rule (ICR) — Federal rule in effect in 1997 requiring water districts serving more than 100,000 connections to monitor for *Cryptosporidium*.

Outbreaks

It was the sixth — and worst — outbreak in 1993 in Milwaukee that garnered the most attention. Nearly half the 840,000 people served by the Milwaukee Water Works became ill after drinking the crypto-contaminated water and 4,400 people were hospitalized. Water frozen for ice production during the outbreak later tested positive for crypto. The precise source of the parasite in the water has never been identified, but possibilities include slaughterhouse wastes, cattle wastes and human sewage.

At the time, the city operated two water treatment plants on Lake Michigan. Only one was implicated in the outbreak, mainly because records indicated an unusual level of turbidity at that plant. Milwaukee's treatment consists of coagulation, flocculation, sedimentation, rapid sand filtration and chlorination, and was in compliance with SDWA requirements. A subsequent study conducted by the Medical College of Milwaukee indicated that other periods of high turbidity at the treatment plant coincided with disease records showing an increase in gastrointestinal diseases from all microbial sources for a 14-month period prior to the 1993 outbreak.

Milwaukee has since adopted stricter standards for operation of its plant and has identified several long-term proposals to improve treatment, including the construction of ozone treatment facilities.

In the case of Las Vegas, it was an increase in laboratory-confirmed cases of cryptosporidiosis from January 1994 to April 1994 that sparked a study of the cause of the disease. (Cryptosporidiosis became a reportable disease in Nevada in 1992.) An epidemiological study conducted by the CDC indicated the outbreak was linked to the drinking water supply, although all samples of water taken during the outbreak tested negative for crypto. Of a total 103 cases, 78 occurred during the epidemiological study period. Of those patients, 61 were either HIV-positive or had AIDS. By 1995, 41 people had died, most of whom were HIV-positive.

Those people infected with cryptosporidiosis lived throughout the area served by the SNWA. Through the use of surveys, CDC epidemiologists asked about the potential forms of infection, including exposure to someone else with the disease. The most common link was drinking tap water. Ninety-one percent of the case study patients drank tap water; only 71 percent of the controls did. Only 8.3 percent of the patients, compared to 28 percent of the controls, drank bottled water exclusively.

To test for crypto in the environment, the organisms must be trapped by a special filter as 100 to 200 gallons of water are run into a collection tank and "concentrated" into a smaller sample of water.

The epidemiological study pointed to three possible sources of crypto in Lake Mead, the source of Las Vegas' drinking water: treated wastewater discharged into the lake from Las Vegas, sewage from boats and a nearby swimming beach. The wastewater, however, is highly treated, and scientists found no malfunction in the waste system at the marina.

"There's tremendous room for error. The present accepted testing method has relatively low recovery rates and can introduce wide variety in the results."

— Rick Danielson, BioVir Lab

The SNWA drinking water plant itself is a modern system that is fully computerized and automated. After chlorination, the water is filtered and treated water from each of the 20 filter beds is monitored for turbidity and particle counting (calculating the size and distribution of suspended solids).

Cryptosporidium, an intenstinal parasite, is found in young

mammals, and studies show that 50 percent of young calves shed crypto oocysts.

No problems were discovered with the SNWA plant or its operation. Although testing for crypto was not mandatory at the time, SNWA had performed monthly tests on the raw water and semi-monthly tests on the treated water since April 1993. Those tests revealed no oocysts.

The AWWA Research Foundation's peer review of the data concurred with the CDC report, concluding that "even under the most stringent and reasonable engineering and technical controls, future outbreaks of this type may occur."

Some skepticism remains that drinking water was the source of the outbreak. Monscvitz, for example, wonders why southern California and Arizona communities that also get water from Lake Mead detected no increase in the number of cryptosporidiosis cases. If Lake Mead wasn't the source of crypto, Monscvitz theorizes that another possibility is that contamination occurred somewhere within the distribution system after the water had left the treatment plant.

Scientists at the CDC, however, say their data shows such a wide distribution of cryptosporidiosis cases that it points to the treatment plant — not the distribution system — as the source of the parasite. As for the question of additional cases of cryptosporidiosis in other states supplied by Lake Mead, Dr. Dennis Juranek at the CDC said there is no routine surveillance for cryptosporidiosis and very little testing except for AIDS patients. In the case of Milwaukee, for example, Juranek said, only one doctor asked for a crypto test.

While surface water systems have been responsible for the greatest number of people affected by the waterborne outbreaks, crypto has been linked to groundwater, too. At the Hydro Nine Irrigation District near Walla Walla, Wash., there were 86 confirmed cases of crypto in 1994 linked to the water supply. At the time, the community's water supply was drawn from two wells, one 500 feet deep and one 600 feet deep. The water supply was generally untreated. One well was not sealed and was located near an area used by livestock and adjacent to an irrigation system that distributes recycled wastewater. After the outbreak officials discovered that recycled water had seeped into that well. City officials have since closed that well and the system now draws its water from the protected well.

In the Lab

A major problem in the struggle to determine how widespread crypto is, and the most effective drinking water treatment, is the test itself. To test for crypto in the environment, the organisms must be trapped by a special filter as 100 to 200 gallons of water are run into a collection tank. The oocysts cannot be seen with the naked eye. In the laboratory samples are stained with a fluorescent dye so they can be detected under a microscope. This method is called an antibody-based immunofluorescence assay, and is the most widely used crypto test in the United States.

Compared to other laboratory tests, the procedure is labor-intensive and expensive — lab costs can run from $300 to $1,000 per sample. Technicians must examine each slide manually, scrutinizing particles that are the correct size to determine if they are crypto oocysts. Even when an oocyst is identified, the test does not allow identification of which species of crypto it is — it could be one of the varieties that is not a human pathogen — or if the oocyst is alive or dead. For example, following the cryptosporidiosis outbreak in Las Vegas, more tests for crypto were conducted and presumptive oocysts (particles that are the right size but lack key identification factors) were detected in the lake water, filter backwash and once in the treated supply.

Estimates of the test's accuracy range from only 10 percent to 30 percent. "There's tremendous room for error," said Rick Danielson, lab director at BioVir Lab Inc. in Benecia, Calif. "The present accepted testing method has relatively low recovery rates and can

introduce wide variety in the results."

Danielson said the test's accuracy could be improved with better concentration and analytical techniques. To date, however, no better way to collect and concentrate the water sample has been developed. Danielson said one way to improve the analytical step is through the use of existing cytometry. A flow cytometer is a machine that can be set to read stained slides and classify and sort particles that are the same size and have the internal structures consistent with crypto. A trained technician can then examine the sorted material to determine if there are any crypto organisms. This can save considerable lab time and allow more samples to be processed. Flow cytometry is used in the United Kingdom, France, Germany, Australia and the Netherlands to detect protozoa in drinking water.

Even with the use of flow cytometers, highly trained, full-time staff still must be on hand to read the samples and confirm a finding with a microscope. This, plus the cost for the equipment itself, would require quite an investment for a private lab.

Scientists continue to work on improving the accuracy of existing lab tests and to develop new ones to detect crypto.

Researchers at the Metropolitan Water District of Southern California (MWD) believe they have developed a new way to test for the parasite. The method, according to MWD, collects organisms much like the current procedure. But instead of relying on visual identification of the oocysts, MWD's procedure extracts DNA from the parasites and replicates it using polymerase chain reaction technology. Analysis of the amplified DNA allows certain identity of the species of crypto detected and determines whether the oocysts are dead or alive. The water agency has filed an application to patent the new technology

In the meantime, EPA officials and water districts are set to begin implementation of data collection criteria based on the immunofluorescence assay test.

Rules and Regulations

As of January, water systems that serve 100,000 or more people must begin to monitor for *Cryptosporidium* oocysts. It is the first step in a multi-year process in which EPA will establish regulations designed to reduce the risk from crypto in drinking water supplies.

Originally enacted by Congress in 1974, the Safe Drinking Water Act's 1986 reauthorization directed EPA to develop standards for 25 new contaminants every three years with a primary focus on reducing the public's risk of cancer. Because the standard chlorine disinfection process produces byproducts suspected to be human carcinogens, there was much interest in reducing exposure to these byproducts by limiting their production.

In the early 1990s, EPA announced

Immune Deficiency

In addition to people with AIDS or who are HIV-positive, other populations more at risk for cryptosporidiosis are the very young, the elderly, certain cancer patients and people who are undergoing a transplant and are on immuno-suppressive medication.

In 1994, California state health officials began warning AIDS patients and other people with compromised immune systems about *Cryptosporidium*. They recommend that people who are concerned about the disease boil their water at a rolling boil for at least one minute.

In June 1995, EPA and the CDC suggested that people with AIDS or other conditions that reduce their immune systems may want to drink only boiled or filtered water, including bottled filtered water. "For the vast majority of Americans, *Cryptosporidium* does not pose a grave danger," the CDC said, but noted that for people with AIDS or who are HIV-positive, "the risk for drinking tap water is not zero."

Home filters can offer varying degrees of protection from microbial pathogens, and CDC recommends that the filter be a microstraining filter that can remove particles 0.1 to 1.0 micron in size. This would include filters that use reverse osmosis, have "absolute" 1.0 micron filters or that meet the National Sanitation Foundation's standards #53 for "cyst removal." Filters that only use ultra-violet light, activated carbon or pentiodite imperegated resins are not effective against crypto, the CDC warns, and filters designed to remove *Giardia* cysts may not be effective against crypto because they are smaller.

CDC guidelines suggest bottled water should follow the same guidelilnes and that the consumer contact the bottler to determine if the filtration method meets their suggestions. Medical officials at the CDC do not recommend counting on bottled water that has been disinfected with ozone because bottlers are restricted to no more than 0.4 milligrams per ozone per liter, which may not be adequate to kill crypto.

it was creating a disinfection and disinfectant byproducts rule (D/DBP) to limit the production of suspected cancer-causing byproducts. These byproducts are formed when chlorine combines with organic materials in drinking water during the treatment process. A common byproduct is known as trihalomethanes (THMs). EPA has proposed that the amount of allowable THMs in the finished water be reduced from 100 parts per million (ppm) to 80 ppm.

"Crypto is a very resilient parasite. The problem with the existing water treatment plants in the United States is even meeting the drinking water criteria, the plants can allow the organism to get through."

— Steve Nugent Carmichael Water District

At the same time, however, the water industry and health officials had begun seriously weighing the lifetime risk of cancer vs. the immediate risk of microbial waterborne disease. EPA's surface water treatment rule (SWTR) that took place in 1989, for example, was designed to address microbial issues such as *Giardia*, *Legionella*, viruses and water turbidity. All surface water systems were required to chemically filter their water unless they met certain criteria. The rule, however, did not address crypto.

With the 1993 crypto outbreak in Milwaukee, control of microbial pathogens took on greater urgency. In 1994, EPA published a notice of proposed rulemaking in the Federal Register that included regulation of *Cryptosporidium*. The proposals included an information collection rule (ICR) to require large water districts monitor for crypto in 1995. Data developed under this rule was to help EPA formulate two subsequent rules: the enhanced surface water treatment rule (ESWTR) and the final D/DBP rule.

The analytical methodology of the ICR became a major issue among water district officials, however, because the test for crypto is considered to be so unreliable. The final rule was delayed for over a year as EPA, AWWA, the Natural Resources Defense Council, and water organizations participated in a regulatory negotiation process. (The D/DBP rule also was delayed and included in the negotiations because surface water treatment is dependent on disinfection.)

In May 1996 EPA signed-off on the ICR, and as of early October, 228 surface water systems began initial crypto monitoring. Testing becomes mandatory for systems serving more than 100,000 people in January 1997. EPA also has begun the process to approve commercial laboratories to perform microbial testing, with 53 facilities and 83 analysts undergoing initial evaluation to determine their ability to perform the protozoa method tests.

The ICR data will help the agency develop the ESWTR, which is expected to be promulgated in 2000. It proposes reduction criteria based on the number of crypto oocysts in raw supplies and will apply to systems that serve water to 10,000 or more people.

The SDWA Amendments of 1996 (PL 104-182) signed into law on Aug. 6 also placed more emphasis on crypto. Striving for balance between adequate disinfection to kill crypto and other microbial agents and reducing the formation of disinfection byproducts during the process will be addressed as EPA formulates the final D/DBP rule. Under terms of the 1996 SDWA amendments, Stage 1 of the rule will be

delayed until at least 2000 with Stage 2 following in 2003.

In California, legislation signed into law in 1996 requires the State Department of Health Services to take all "reasonable measures necessary to reduce the risk to public health from waterborne illnesses in drinking water." The bill, SB 1307, introduced by state Sen. Charles Calderon (D-Montebello), repeals the requirement that the state's drinking water systems meet "recommended public health goals," standards that were even stricter than national rules set by EPA.

The bill directs State Department of Health officials to implement the department's *Cryptosporidium* action plan to facilitate compliance with existing surface water treatment requirements. Under the new law, the state can require water agencies to conduct sanitary surveys of their water source and pathogen source control and submit certain data to the state. The law also requires the department to present a report to the Legislature on the progress of the plan in January 1998. The report will describe actions taken to reduce exposure to crypto in water supplies, recommend additional actions necessary to protect public health, and describe progress made on implementation of the federal ICR.

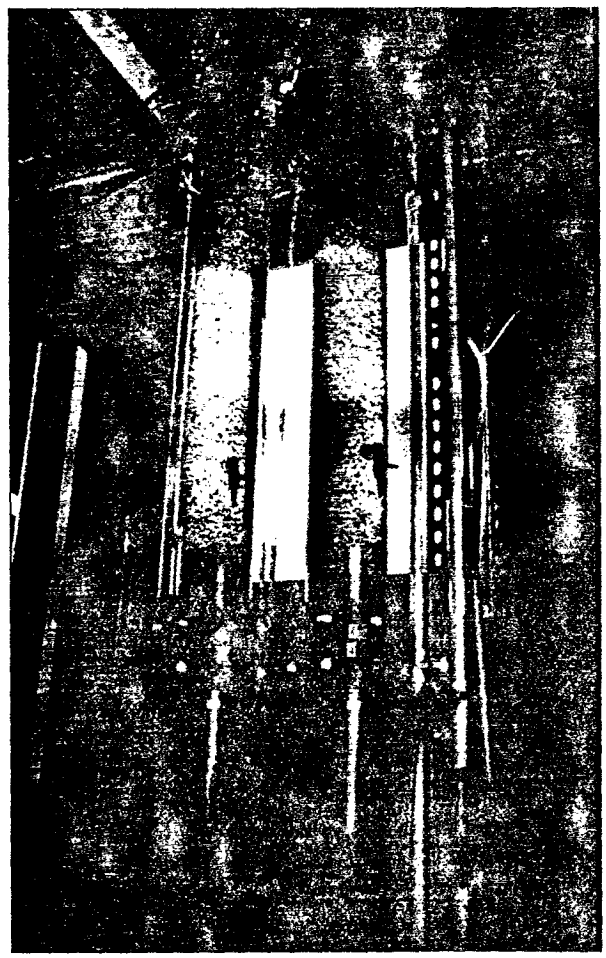
As federal and state officials develop rules to regulate crypto, water suppliers have taken steps to enhance existing treatment systems to further reduce the risk of a water-borne *Cryptosporidium* outbreak. In 1995, EPA and AWWA initiated a joint, voluntary program known as the "Partnership for Safe Water." About 28 California water agencies belong to the national group. Participating water systems are asked to review the design, maintenance and operation of their treatment systems and then voluntarily make any refinements necessary to reduce risks from crypto and other microbial pathogens.

The California-Nevada section of AWWA held eight workshops in 1996 to address the optimization of water treatment facilities to remove crypto. Water personnel from more than 300 systems attended the workshops.

Water Treatment Options

Although water utilities were not required to test for crypto until EPA developed the ICR, some California water providers have conducted voluntary tests. The findings, according to state health officials, show that "the risk of healthy individuals contracting cryptosporidiosis from drinking water in California is extremely low."

Data submitted to the state Department of Health Services in 1994 and 1995 (based on the number of oocysts per 100 liters of water), showed a range of less than 1 to 5.3 oocysts per 100 liters of *treated* drinking water and from less than 1 to 132 oocysts per 100 liters of *untreated* drinking water sources, with State Project Water from the Delta containing the highest levels. Since 1989, there only have been 1,396 total reported cases of cryptosporidiosis in California — none has been linked to drinking water.



Ozone gas, which can rupture the cell walls of parasites, bacteria and viruses when passed through water is the only known disinfectant that appears to work against crypto. Above, the interior of an ozone treatment plant.

"*Cryptosporidium* is cause for concern, but not cause for alarm or panic," said Roy Wolfe, associate director of water quality at MWD. "Every utility needs to be monitoring for it, working to treat it and communicating with the public and health officials, but for the average person, it's not a reason to panic."

Still, officials at many water utilities have taken aggressive steps to improve existing treatment systems and monitor for the parasite, and a number are considering upgrading treatment plants for better control.

"Crypto is a very resilient parasite. The problem with the existing water treatment plants in the United States is even meeting the drinking water criteria, the plants can allow the organism to get through," said Steve

According to the CDC, *Cryptosporidium* — crypto for short — has been found in 65 percent to 97 percent of the nation's rivers, lakes and streams. Through data submitted by water districts, California health officials have determined that the parasite can be found in low concentrations in the state's surface water.

Nugent, assistant manager of the Carmichael Water District, located in suburban Sacramento.

The district recently certified an environmental impact report on a new microfiltration plant and is planning to put the project out for bid in March. Carmichael Water District, which serves a population of 38,000 people through 11,000 connections, began looking at new treatment options in 1993 after it was notified that its existing Ranney filter system was out of compliance with the federal SWTR. The existing filter consists of a concrete cylinder cassion constructed in the ground with horizontal perforated pipelines collecting water from underneath the American River. Natural sand and gravel is used to filter the water as it is pumped out below the river. Chlorine is then added as a disinfectant prior to distribution.

When the district was ordered to conduct additional tests of the water, it detected *Giardia* and *Cryptosporidium* organisms twice after passing through the filters, although none of the parasites was ever detected at the tap. The district studied 29 alternatives to meet the SWTR and ultimately decided on a microfiltration plant with membranes capable of removing particles as small as 0.2 microns.

Construction of the plant will cost $15 million plus an additional $9 million to improve the existing water distribution system. According to Nugent, the cost was comparable with a conventional treatment plant. Although the plant uses more energy, he said it will use fewer chemicals and require fewer employees to operate. The district has raised rates 91.5 percent since 1993 to pay for the plant, but still average only $24 a month.

The filter will create a physical barrier for crypto and allow the district to provide water that is safer for everyone to drink, said Curtis Spencer, a member of the district's board of directors. "I think it's been demonstrated through quite a number of public health outbreaks that it is quite a problem and water treatment plants have to be operated to protect all sectors of the public," he said.

Membrane filtration is considered a very effective way to eradicate crypto, but it isn't cheap. EPA estimates that for water systems serving more than 10,000 users, the additional cost of a membrane system would be between $96 and $180 per household per year.

While waterborne crypto outbreaks have occurred in surface water systems with conventional filtration, the analysis conducted by Solo-Gabriele and Newmeister found that an outbreak usually followed some sort of problem with the system. Other studies, according to the CDC, have found that small numbers of crypto oocysts were able to breach filters and were present in the tap water in 27 percent to 54 percent of communities evaluated.

Some people in the water industry, however, say that regular granular, media filtration — properly operated — is very effective at removing crypto oocysts. Through the voluntary Partnership for Safe Water, said MWD's Wolfe, water utilities are being asked to produce water with the lowest turbidity level possible. (Turbidity, the clarity of the water, once was viewed as mainly an

aesthetic issue, but now is believed to be an indicator of the presence of microorganisms.) The key, he said, is for the system to monitor the turbidity at each individual filter rather than averaging the overall turbidity as is allowed under current SDWA regulations.

Filtration is important because other tests have shown that the chlorine concentrations necessary to inactivate crypto are much higher than those used in conventional treatment. This, again, raises the issue of disinfection byproducts and their effect on public health.

Some water districts are investigating the use of an alternative disinfectant that is effective against crypto and other microbial agents — ozone. Ozone gas, which can rupture the cell walls of parasites, bacteria and viruses when passed through water is the only known disinfectant that appears to work against crypto.

Ozone was first used as a disinfectant in Europe where it remains in wide use today. A drawback of the process is that it forms no residual disinfectant so chlorine has to be added after the water is treated to kill any bacteria in the distribution system. Ozone also improves the taste and odor of water, but it's expensive to retrofit existing plants. Aieta, of CH2M Hill, estimates that ozone is 10 times more costly on an annual basis with capital costs for ozonation facilities up to 1,000 times greater than conventional chlorination.

MWD staff, Wolfe said, estimates the cost of switching to ozone at its five treatment plants at $575 million. The agency has no immediate plans for making the change. In 1995 MWD's board did approve a $1.5 million crypto action plan that includes increased water testing, research and public information. MWD has found crypto twice in its water. During routine sampling in 1991 and 1992, MWD found crypto once in an uncovered reservoir of treated water and once at a treatment plant. The concentrations in *treated* water averaged .02 oocysts per 100 liters of water and in *raw* water 0.1 oocysts per 100 liters of water.

A new ultraviolet irradiation device developed by Water Recovery Place, a firm headquartered in England, has shown promise in killing crypto oocysts for systems with 12,000 or fewer connections. The device is the first successful crypto treatment method tested as part of an ongoing program by the AWWA Research Foundation and the Electric Power Research Institute.

The Future

While research continues on finding a reliable way to test for and eradicate *Cryptosporidium*, drinking water officials say the best protection now is an aggressive, multiple barrier approach. Such a program would include source water protection, better filtration with traditional facilities, an effective cross connection program to ensure drinking water pipes are protected from potential sources of crypto, and use of ozone if necessary.

Water and health officials also must address the question of risk vs. cost. The issue was an overriding theme in the debate over reauthorization of the SDWA, which now requires EPA to conduct a benefit-cost analysis on proposed new regulations. (This clause does not effect crypto because the negotiated ICR and D/DBP schedule was grandfathered into the law.)

A report released in 1996 by a group of 65 international experts warned that the list of potentially pathogenic organisms in water is increasing annually. The scientists said that microbiologically safe drinking water can no longer be assumed and called for improving risk assessment methodology and database development of waterborne diseases, implementing active surveillance of such diseases and educating the public about the burden of waterborne disease.

As technology continues to advance, health and water officials will continue to face the question of whether it is possible to obtain zero risk of contaminants — chemical or microbiological — in treated drinking water, and whether society as a whole is willing and able to foot the bill to reach that goal. ∎

More Information

How to prepare for a *Cryptosporidium* outbreak, survey for disease and test for crypto are topics discussed in a new handbook being developed by the CDC's Working Group on Waterborne Cryptosporidiosis. The handbook, scheduled to be published in early 1997, was written by several national experts and will be distributed directly to health officials in communities throughout the United States. Copies also will be available from AWWA, 1-800-926-7337.

EPA has established a national hotline system for reporting or obtaining information about waterborne cryptosporidiosis: 1-800-424-8802. The CDC has a web site on the World Wide Web offering information on cryptosporidiosis: http:\\www.cdc.gov/ncidod/diseases/crypto/crypto.htm